ITEA Journal 2011; 32: 29–38

Establishing the Integrated Test Concept

Maj Douglas F. Kaupa and Michael A. Whelan
Air Force Institute of Technology (AFIT),
Wright-Patterson Air Force Base, Ohio

Developing integrated test concepts for aircraft requires close interaction between contractors, acquisition officials, system users, U.S. Air Force test agencies, and the Federal Aviation Administration. Integrated test emphasis within the Department of Defense arrived at a prominent time to make a positive impact on the C-130J, KC-X, E-3 DRAGON,[1] and Joint Cargo Aircraft test programs. Mobility and surveillance airframes are exceeding corrosion and fatigue models based on greater flight rates, requiring new assets more swiftly. All stakeholders in the programs have a vested interest in making the test and evaluation program as efficient as possible. This article reviews Department of Defense integrated test concept, identifies operational test characteristics required by public law, and discusses integrated test methods, which comply with law and policy. Implementation challenges are also discussed, including mobility and surveillance aircraft test community methods addressing integrated testing challenges, tracking test events, and identifying integrated test opportunities.

Key words: Acquisition team; aircraft test; collaboration; contractor test; developmental test; FAA certification; law and policy; operational test; weapons systems.

Operational Test and Evaluation (OT&E) ensures the warfighter is provided with suitable and effective weapon systems. To rapidly provide new or modified systems for our airmen, the acquisition process requires greater efficiency. Increasing T&E effectiveness can assist this effort. Integrated weapon system testing combines Contractor Test (CT), Developmental Test (DT), and Operational Test (OT). Integrated tests have the potential to shorten acquisition timelines, while balancing cost, performance, and schedule requirements. DT and OT terms used in this article are broad statements for a type of T&E, not terms used to describe testing controlled by any one particular organization.

In a Joint memorandum, dated 25 April 2008, the Director of Operational Test and Evaluation and Deputy Undersecretary of Defense for Acquisition and Technology defined Integrated Testing (IT) as "The collaborative planning and execution of test phases and events to provide shared data in support of independent analysis, evaluation and reporting by all stakeholders particularly the DT (both government and contractor) and OT communities" (McQueary and Finley 2008).

IT is more than combining developmental and operational testing. IT is establishing a test process that fully synergizes all stakeholder objectives into a single continuum with the goal of achieving the most effective, efficient test program possible. The scope includes CT, DT, OT, and, in the case of the KC-X and Joint Cargo Aircraft (JCA) programs, the Federal Aviation Administration (FAA) certification activities. Today, DT involves both government and contractor test organizations, ensuring weapon system specifications are met. However, some data produced by DT and properly conducted test events satisfying U.S. Code, Title 10, Section 2399, "Operational Test and Evaluation of Defense Acquisition Programs" can support operational T&E needs. Integrated DT and OT planning and execution can reduce total test expenditures and timelines.

What does this mean for all stakeholders in an acquisition program? Data from an IT can be used by the contractor for design improvements, by developmental evaluators for risk assessments, and by the operational evaluators for operational assessments. Early and open communication between all parties within the acquisition team is a must! The user, program office, contractor, DT, and OT testers must be active early in a program before a request for proposal is delivered to potential

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **MAR 2011**	2. REPORT TYPE	3. DATES COVERED **00-00-2011 to 00-00-2011**
4. TITLE AND SUBTITLE **Establishing the Integrated Test Concept**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air Force Institute of Technology (AFIT),Wright-Patterson AFB,OH,45433**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**10**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

contractors. IT can better use limited resources such as test assets and ranges, eliminate redundant test events, and reduce the overall program cost and schedule. The Department of Defense (DoD) recognizes the potential benefits and has directed implementation of the integrated test concept.

DoD integrated test concept

Integrated testing is not a new concept within the DoD. The concept existed in the May 2003, Department of Defense Instruction (DoDI) 5000.2, Operation of the Defense Acquisition System. However, the policy was neither well defined nor consistently implemented in the acquisition process. The DoD further refined integrated test direction with the revised DoDI 5000.2 in December 2008. The new instruction refines integrated test concepts to include the following direction (emphasis and acronym definitions added):

> *"EMD [Engineering Manufacturing and Development] effectively integrates the acquisition, engineering, and manufacturing development processes with T&E [Test and Evaluation] (see Enclosure 6). T&E shall be conducted in an appropriate continuum of live, virtual, and constructive system and operational environments.* Developmental and operational test activities shall be integrated and seamless throughout the phase. *Evaluations shall take into account all available and relevant data and information from contractor and government sources" (DoD 2008, 24).*

Additionally, the new DoDI directs "Integrated Test" in the following manner (acronym definitions added):

> *"The PM [Program Manager], in concert with the user and the T&E community, shall coordinate DT&E, OT&E, LFT&E [Live Fire Test and Evaluation], family-of-systems interoperability testing, information assurance testing, and modeling and simulation (M&S) activities into an efficient continuum, closely integrated with requirements definition and systems design and development. The T&E strategy shall provide information about risk and risk mitigation, provide empirical data to validate models and simulations, evaluate technical performance and system maturity, and determine whether systems are operationally effective, suitable, and survivable against the threat detailed in the STAR [System Threat Assessment Report] or STA [System Threat Assessment]. The T&E strategy shall also address development and assessment of the weapons support equipment during the EMD Phase, and into production, to ensure satisfactory test system measurement performance, calibration traceability and support, required diagnostics, and safety. Adequate time and resources shall be planned to support pre-test predictions and post-test reconciliation of models and test results, for all major test events" (DoD 2008, 50).*

The U.S. Air Force Operational Test and Evaluation Center (AFOTEC) Director of Operations released a memorandum on 17 October 2008 to operational test planners stating: "As testers, we can affect the cost-schedule-performance problem facing program offices by making better use of limited test assets and test ranges to eliminate unnecessary overlap of test events, better assure that systems are ready for OT, and reduce the overall time required for testing" (Eck 2008).

The AFOTEC commander has taken the integrated test concept one step further, directing OT plans to incorporate integrated events. He has directed OT planners to develop plans and concepts earlier to facilitate integrated test planning. *Figure 1* shows the OT early planning concept. At Milestone A, or key decision point, the OT planners provide an initial OT design to support development of IT in the T&E strategy. At Milestone B, the OT design is expanded as the system capabilities are further developed and defined. Between Milestone B and C, the OT design becomes a detailed test plan and is documented in an Integrated Operational Test and Evaluation (OT&E) plan. Throughout the acquisition process, the availability of the OT design is used to influence contractor and DT planning and to support IT. After the AFOTEC commander approves the OT&E plan with integrated events, the plan will be sent to the Program Executive Officer (PEO) for acknowledgment regarding OT use of the integrated events to ensure their execution. The PEO has a vested interest in ensuring efficient test execution.

Combining DoD and AFOTEC commander's direction together, the key characteristics required for integrated test are as follows:

1. collaborative planning and execution of test events;
2. shared data;
3. stakeholder independent data analysis, evaluation, and reporting;
4. establishing risks and risk mitigation to decision makers in a timely manner;

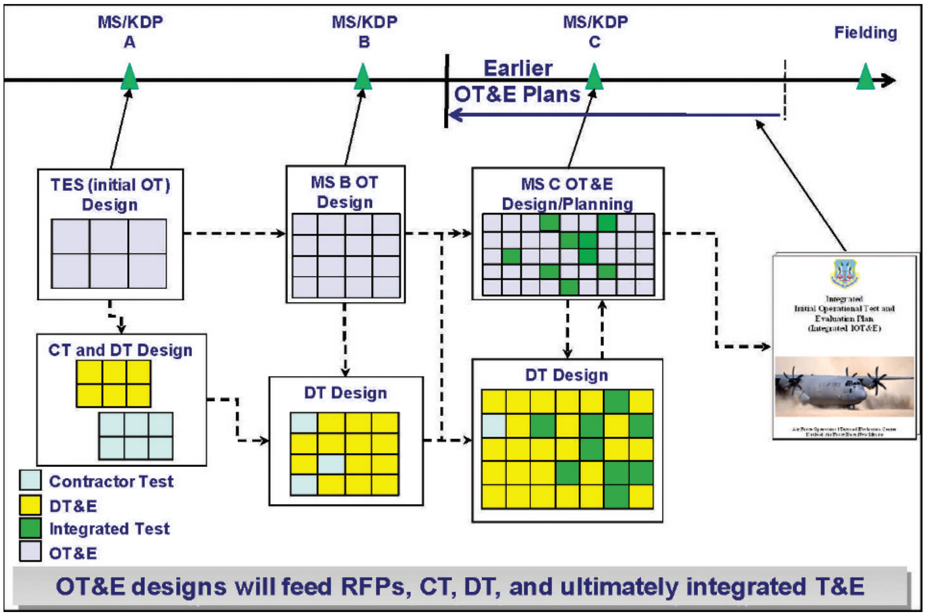

Figure 1. Earlier operational testing planning concept.

5. efficient use of limited assets, reducing overall time required for testing;
6. elimination of unnecessary overlap of test events; and
7. documentation in an OT&E plan with integrated events signed by the OT commander and acknowledged by the PEO.

Operational test public law limitations

Blending the direction of senior DoD leaders with public law governing OT is challenging. Title 10, section 2399, Operational Test and Evaluation of Defense Acquisition Programs, contains clauses that make IT difficult; in particular,

> *"(d) Impartiality of Contractor Testing Personnel — In the case of a major defense acquisition program (as defined in subsection (a)(2)), no person employed by the contractor for the system being tested may be involved in the conduct of the operational test and evaluation required under subsection (a). The limitation in the preceding sentence does not apply to the extent that the Secretary of Defense plans for persons employed by that contractor to be involved in the operation, maintenance, and support of the system being tested when the system is deployed in combat" (10 USC 2399).*

For IT, claiming "credit" regarding an event for OT purposes becomes a challenge when contractors are involved. The contractor is quite clearly engaged in most DT and by definition in any CT. However, there are methods available to ensure the operational testers conduct the test event, even though during other test events during the test period the contractor is involved. Title 10, Section 139, "Director of Operational Test and Evaluation (DOT&E)" defines operational test and evaluation as follows:

> *"(A) The term "operational test and evaluation" means - (i) the field test, under realistic combat conditions, of any item of (or key component of) weapons, equipment, or munitions for the purpose of determining the effectiveness and suitability of the weapons, equipment, or munitions for use in combat by typical military users; and (ii) the evaluation of the results of such test" (10 USC 139).*

The key words here are "field test, under realistic combat conditions" and by "typical military users." There is no clear definition what the terms mean, so operational testers must exercise reasonable judgment. Generally, contractor and developmental test conditions are not realistic combat conditions by design. Contractor and developmental testing is conducted under controlled conditions designed to evaluate the system, subsystem, or function, which is the focus of the test. The uncontrolled conditions inherent in realistic combat conditions conflict with a normal structured test approach. Again, there are times and places where conducting a test event under

realistic combat conditions with typical military users can meet contractor and DT needs and fulfill OT needs.

DoDI 5000.2 further requires the following from OT&E:

> *"The independent planning of dedicated IOT&E (i.e., the OT&E required by paragraphs (a) and (b) of section 2399 of Reference (k)), and Follow-on OT&E (FOT&E), if required, shall be the responsibility of the appropriate OT agency (OTA). Evaluations shall include a comparison with current mission capabilities using existing data, so that measurable improvements can be determined. If such evaluation is considered costly relative to the benefits gained, the PM shall propose an alternative evaluation approach. This evaluation shall make a clear distinction between deficiencies uncovered during testing relative to the approved requirements and recommendations for improvement not directly linked to requirements. A DOT&E-approved LFT&E strategy shall guide LFT&E activity" (DoD 2008, 24).*

> *"During OT&E, a clear distinction shall be made between performance values that do not meet threshold requirements in the user capabilities document and performance values that should be improved to provide enhanced operational capability in future upgrades" (DoD 2008, 50).*

> *"The Department of Defense may not conduct OT&E, including operational assessment (OA), IOT&E, or FOT&E, until the DOT&E approves, in writing, the OT&E portions of the T&E plan for programs on the Office of the Secretary of Defense (OSD) T&E Oversight List and the adequacy of the plans (including the projected level of funding) for the OT&E to be conducted in connection with that program. This does not preclude the use of data from other test events in OT&E evaluations. OTA and DOT&E evaluators shall take into account all available and relevant data and information from contractor and government sources" (DoD 2008, 25).*

The duty of the integrated test planner is to blend DT, often conducted with the contractor, together with OT, while complying with public law and senior DoD leadership direction. Additionally, the OT planner must balance policy guidance and design a highly efficient T&E framework to meet shorter schedule and smaller budget constraints.

Overcoming operational test public law limitations

Public law directs that operational tests employ production representative test articles and are conducted under realistic combat conditions by typical military users. These directives appear to conflict with the DoD guidance regarding IT. In reality, conducting aircraft IT events for OT "credit" is not difficult. Meeting the "typical military user" and "realistic combat conditions" requires coordination with the developmental testers. Arranging a particular test event to have an OT crew, in most cases, is a simple aircrew scheduling problem. Flying the test event under realistic combat conditions can also be accomplished without significant effort.

Most aircraft test teams include both an operational and developmental test contingent. DT normally follows a "build-up" approach, where early test points are designed or constrained to evaluate specific conditions. Later, test points generally are less constrained and are perfect opportunities to implement an integrated test event counting for operational test credit. Planning for the OT team contingent to conduct these less stringent test points under operational conditions allows a corresponding reduction in the separate OT events. The test planners integrate evaluation requirements to effectively accomplish the test event, while providing data for each stakeholder. The test planners attempt to ensure that test events accomplished in DT are not replicated in OT.

For example, in recent C-130 J aircraft defensive system evaluation, DT and OT evaluators were able to integrate several test events. During DT of a radar warning receiver, the last hour of range time was used by OT, flying operational scenarios against the same systems used by DT earlier in the flight. By conducting the test events in this manner, testers reduced the acquisition program's expensive range costs, test flight hours, schedule, and total number of test sorties required. Additionally, the DT team gained an understanding of the subsystem performance when combined with operational tactics and procedures. Some key system characteristics were identified during the test planning, which facilitated the integrated test planning. First, the system development was stable, and the risk of major changes to the hardware or software were minimal (i.e., the system could reasonably be called "production representative" for public law OT purposes). Second, the cost and schedule difficulties associated with the range time and aircraft sorties were identified as areas where IT could significantly impact the overall acquisition program cost and timeline.

Even when specific DT events fail to meet public law criteria for OT, the events can still positively

impact OT events and thus the program's cost and schedule. Unless specified in a requirements document, the confidence needed in a specific performance requirement is an OT subjective determination. Operational evaluators have the planning latitude to address areas where operational risk or impact appears greatest or reduce the number of test events required where the operational risk or impact appears low. Using test event data from DT to assess risks can reduce OT cost and schedule. For example, if DT confirms an aircraft's precision approach and landing capability through numerous test events to satisfy FAA requirements, the operational planner could assume the system performance operational risk is low and significantly reduce the total number of OT events evaluating precision approach and landing capabilities. As straight forward as the concept is, the operational evaluators must address several IT implementation hurdles before securing shared data, especially for the KC-X program.

Integrated test implementation challenges

The KC-X integrated test planning effort faces various barriers; foremost is the contracting process. The current acquisition strategy identifies using a commercial derivative aircraft complete with FAA certifications.[2] Achieving appropriate certifications is left to each bidding contractor and is an area of competition for determining the eventual contract winner. In order to support IT prior to source selection, each contractor would need to interface with the complete test community to develop an integrated test and then include the developed plan as part of their proposal, a significant concern for most contracting officers. Without some alternative method, developing an executable integrated test requires coordination with the winning contractor after source selection, when changing the contract to accommodate specific IT events may cause expensive contract modifications.

The FAA aircraft certification process differs significantly from the Air Force (AF) process. In particular, without specific wording in the contract, data submitted to the FAA for certification will not be available to the AF test community. The approach conflicts with the shared data characteristic outlined in DoD directives. Since the acquisition strategy currently calls for a commercial derivative aircraft, test data and methods are competitive factors among contractors (not only for the KC-X contract but also in all their business ventures) and will likely be a discussion item within the contract negotiations. Additionally, the FAA is the approval authority for the certification process, and integrating the FAA test events with other test events as well as obtaining required approvals from all stakeholders poses further challenges.

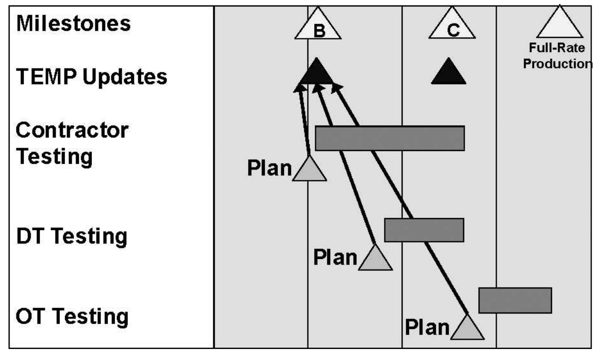

Figure 2. Conceptual test planning timelines.

Developmental and operational test planning timing issues also challenge implementing IT. *Figure 2* illustrates the nominal timing issues and shows where test events are normally created. The figure also illustrates where test planners need to know all the events to integrate them effectively. Currently, test-planning timelines are not arranged to facilitate integrated test planning. Normally, CT plans are produced before DT plans, which are produced before OT plans. To completely chart an IT in one iteration requires contractor, developmental, and operational test planners working simultaneously, communicating and integrating test events among themselves. The DoD recognizes the need and specifically calls for collaborative test development as an IT characteristic. To perform collaborative planning, developmental and operational planners are required earlier in the test planning process. How early depends upon the specific program.

Additionally, implementation of an integrated test plan is challenging. Perhaps the program's Test and Evaluation Master Plan (TEMP) should become the repository of integrated test events. Establishing the TEMP as the repository of integrated test events permits the visibility of the required events and allows detailed test planning to mature with the program. The TEMP supporting milestone B (the decision point within the DoD acquisition system to begin system engineering and demonstration) would have detailed CT information, general DT detail, and conceptual OT detail. At milestone C (the decision point within the DoD acquisition system to begin production and deployment), the TEMP could be revised, adding details to the developmental and operational test sections. Because the TEMP would include most test events, execution of events, and test cost, the schedule optimization should naturally occur through the TEMP review processes already in place. The totality

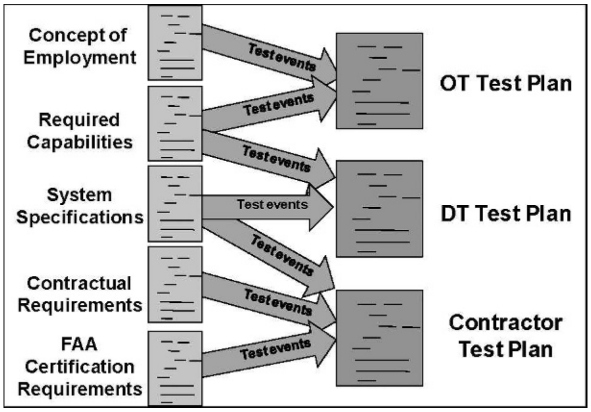

Figure 3. Non-integrated approach.

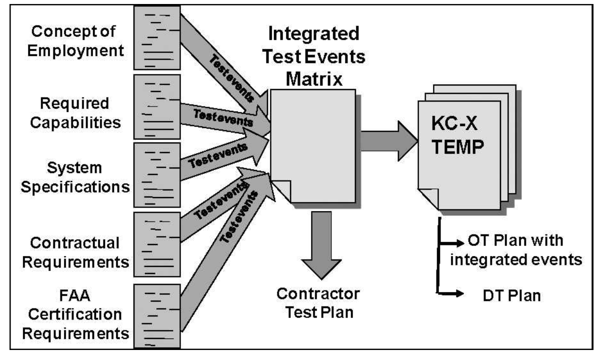

Figure 4. Integrated test approach conceptual diagram.

of the test events should be evident, clearly identifying which events support both DT and OT. A method to efficiently handle changes is required and is beyond the scope of this article. Both test planners and senior DoD officials should be able to capitalize upon the visibility, combining OT planning with DT test events, and optimize test expenditure and schedule.

Figure 3 illustrates the source documents for key test events for a program. OT plans are developed from concepts of employment and required capabilities documents. DT plans are derived from required capabilities documents and system specifications. For most programs, there is not a single DT plan. Instead, different DT agencies develop test plans addressing the test events they are chartered to test. So, while shown here as a single document, there may be many DT test plans. Contractor test plans are developed from system specifications, contractual requirements, and in this case, FAA certification requirements. Each of the documents is related and may contain the same requirement specified in different ways. Development of the OT, DT, and CT plans separately increases the probability that the multiple plans may contain duplicative test events. A method of integrating all of the events derived from the source of the requirement, where each organization can see the test events in totality, is required. Establishing informative methods to reduce duplication is the ultimate goal of IT. The KC-X, JCA, and E-3 DRAGON programs are pursuing the integrated concept by identifying test events early, combining them, and minimizing the test footprint, with the goal to field aircraft systems more rapidly.

Current integrated test planning approaches

The KC-X test community includes developmental and operational testers, FAA, program office, and DOT&E personnel. The test community established an Integrated Test Team (ITT), which meets regularly. At the meetings, the team defines required information to develop integrated test events and creates a process to capture and communicate those events.

The first challenge the KC-X ITT overcame was development of a conceptual framework to plan IT. After numerous discussions, the ITT decided the best IT implementation approach started with the source documents shown in *Figure 3*. Rather than employing the source documents individually to create separate contractor, DT, and OT plans, the ITT decided to collect all the test events together into an Integrated Test Events Matrix (ITEM) as a document that can highlight test duplication and redundancy. *Figure 4* illustrates the concept. The ITEM could become a source document for TEMP development or perhaps be included within the TEMP. With the ITEM and TEMP, the respective test organizations can develop their individual test plans and include them with the TEMP as attachments. Additionally, the program office can use the ITEM to communicate to potential contractors the desired nature of the integrated test. The process could have the TEMP functioning as the ITEM repository, and individual test plans would support execution of the IT described in the TEMP.

To affect KC-X IT, the team concluded that each test event needs to be described in terms of the following four descriptive tables:

- *Table 1*: Source – Requirements that drive test event or activity needs. Examples include the Capabilities Development Document (CDD), System Requirements Document (SRD), Concept of Employment (CONEMP), Statement of Objectives (SOO), or civil certification plan requirements.
- *Table 2*: Description – A definition of the system, subsystem, or function evaluated, highlighting the objectives, participating test organizations, test methodology, measures, metrics, and performance criteria. Included are the test event–

Table 1. Source documentation driving test requirements.

Source					
Describe which requirement(s) dictate the particular test to be conducted (e.g., RFP, certification plan, or other requirement source paragraph)					
CDD	**SRD**	**Supportability requirements**	**Certifications**	**CONOPS/ CONEMPS**	**SOO**
CDD language associated with the particular test, if applicable	SRD language associated with the particular test, if applicable	Supportability requirements that are the basis for the particular test, if applicable	Certification that dictates the particular test, if applicable	CONOP/CONEMPs that dictate the particular test, if applicable	SOO language that dictates the particular test, if applicable

CDD, Capabilities Development Document; SRD, Systems Requirements Document; CONOPS, concept of operations; CONEMPS, concept of employment; SOO, statement of objectives.

dependent thresholds to verify a successful test completion and the method to complete evaluation (not shown), such as inspection, analysis, ground or flight demonstrations or laboratory tests.

- *Table 3*: Conditions – The system configuration, test environment, and personnel essential to conduct the test. The condition section is key in determining if combined testing is possible. Here is where the test planner can begin to see different situations separating contractor, DT, or OT planning. Some tests may be integrated, as permitted by law and DoD direction, and are continued into the resources section.
- *Table 4*: Resources – Test articles, support equipment, simulations, models, facilities, and personnel required. The Resource portion can also identify resources that can be shared once integrated testing is deemed valid. For instance, contractor, developmental, and operational testers can share aircraft generation equipment if the equipment is listed early in the program. Duplicated resources can be highlighted and reduced. Further, test range activities, one of the more expensive test resources, may be combined, permitting more programs earlier opportunities for evaluation.

The C-130J program has taken another approach. Two different follow-on operational tests have integrated developmental and operational events. The C-130J ALR-56M radar warning receiver tests required range support for both DT and OT. Range costs and setup times were recognized by both communities as likely integrated test cost-savings areas. The testers combined OT with the DT mission by loading more chaff and performing some OT events at the end of each DT mission. OT "purchased" the last hour on the range for numerous tests at higher/lower altitudes, airspace and terrain masking events highlighting more operationally realistic activities. The concept required early test planning for both entities. The integrated test concept gave OT more data and made the best use of range time plus maintenance support and other flight-related assets. Further, OT observed early DT

Table 2. Overall test event description.

Test Description					
Describe each test to be conducted. Include, as a minimum the system, subsystem or function to be tested, the objectives for the particular test, participating test organizations, the applicable testing methodology, measures and metrics, and the acceptable range/threshold, for each of the metrics, that indicates a successful test completion.					
Subsystem/ function	**Test objectives**	**Test organization**	**Test methodology**	**Measures and metrics**	**Acceptable range/threshold**
Primary subsystem/ function to be tested (include related systems in parentheses if desired).	Primary objective or purpose of the particular test (secondary objective can be included in parentheses).	RTO for the particular test (PTOs can be listed in parentheses).	The desired testing methodology for this particular test (secondary, tertiary, etc. methodologies should be listed in parentheses and in order of preference).	The one primary metric to be used to evaluate test results (additional metrics can be included in parentheses).	The success threshold and/or range of results for the primary metric to be used for this test (additional thresholds and/or ranges can be listed in parentheses as a one-to-one match for the metrics/measurements listed in the preceding column).

RTO, responsible test organization; PTO, participating test organization.

Table 3. Test event conditions.

Conditions			
Describe the conditions under which the test shall be conducted. Include, as a minimum, the testing configuration, the testing environment, and any desired test crew or test conductors in addition to those provided by the contractor.			
Configuration	**Environment**	**Combined testing? (Y/N)**	**Crew/Tester**
The physical configuration for the object to be configured to conduct the test.	The desired physical environment for the particular test (e.g., standard day, no wind).	Indicate if more than one testing organization can be involved with the particular test.	The primary crew and/or test conductor for the particular test (additional crew/testers can be listed in parentheses).

assessments into the effectiveness and suitability of the ALR-56M defensive system, fulfilling OT-dedicated testing. C-130J testing continues today with a formation station keeping equipment evaluations. Both communities are repeating the integrated planning and execution process as DT and OT flights accomplish similar assessments. For example, the OT community is planning to use data from DT flights that chase instrument meteorological conditions as part of the OT test data. Integrating these tests allows the program to evaluate very specific events once without having to repeat these tests during OT. Having the combined DT/OT events permits OT to reduce the overall test footprint, fulfilling aircraft verification and validation more swiftly.

The E-3 DRAGON program adds another layer to the KC-X ITEM concept with requirements integrating tests with NATO Airborne Warning and Control System (AWACS). One additional section lists commonalities between the U.S. and NATO aircraft, while highlighting NATO's proximity to the Southwest Asia and Arctic theaters; whereas the U.S. is nearer to the international dateline, Eastern Asia and Australia. If the commonalities between U.S. and NATO aircraft are sufficient, DT and OT could be divided and information shared, reducing overall flight-hour costs and schedule.

The KC-X program has created new IT approaches. Bidding contractors are mandated to conduct cold/hot weather testing and also include IT by requesting that DT ensure verification of subsystem operations and by requesting OT conduct a preflight, ensuring that crews in cold/hot environments can successfully perform a mission. Further, the KC-X program has requested type-I contractor training to be conducted concurrently with mid-phase EMD testing. For instance, OT crews will be certified flying the KC-X EMD aircraft before MS-C and maintain currency by conducting some take-offs and landings on a typical DT mission planned for a range evaluation. Taking IT one step further, OT can conduct radio evaluations to/from a planned DT test range if the sortie length between takeoff and range entry permits.

KC-X OT crews will participate in receiver aircraft certifications, both on the KC-X as a tanker and various multi-seat aircraft receivers. DT and OT events are combined before the first government air refueling flights reviewing KC-X suitability and effectiveness as early as possible. DT-only missions will cover the first couple of air refueling sorties, demonstrating safety and air refueling system maturity. If no major air refueling subsystem warrants change, such as boom flight controls, then OT can jointly fly on following sorties

Table 4. Test event resources.

Resources					
Describe the physical resources required for successful test completion. Include, as a minimum, articles required for the test, the supporting assets (e.g., chase aircraft and so on) needed and the simulations, models, test beds, facilities, and other personnel besides the primary testing crew or test conductors.					
Test articles	**Supporting assets**	**Simulations, models, and test beds**	**Facilities**	**Personnel**	**Special**
List articles required for the particular test.	List equipment or other physical assets that are required for the test (e.g., chase aircraft, software version type, etc.).	List simulation, model, or test bed needed for the test (e.g., SIL, Iron Bird, computational fluid, dynamics software, structural loads software models, etc.).	List primary testing facility to conduct the test (secondary or related facilities can be listed in parentheses).	List personnel other than the primary crew/testers who are required to conduct the particular test.	List resources the primary testing facility does not possess necessary to conduct the test.

testing various altitudes, offload quantities, and lighting conditions; thus minimizing test flights to verify and validate receivers.

The Joint Cargo Aircraft program also is combining DT and OT events to perform integrated testing. Like the C-130J ALR-56M testing, the range time required to conduct defensive system testing is one area considered for IT. The risk of changes to the defensive system had been considered higher for this program, so inside of conducting integrated test events at the end of each DT mission, all the OT missions are planned to occur during the last 2 weeks of the defensive system testing. The test teams chose this method to allow DT and the program office to make changes required prior to the OT events but still reap the cost and schedule savings. OT events will still occur when the aircraft is already at the range instead of another deployment to the ranges at a later date.

AFOTEC is committed to an early influence process supporting and enhancing acquisition programs. Involvement in the KC-X and C-130J electronic warfare range testing and formation test programs over the past 2 years has illustrated the commitment. Constructing an ITEM to support IT development for the KC-X program is just one example. Aiding system training requirements refinement, assisting development for concept of employment documents with the user, and identifying potential acquisition issues affecting test are further steps AFOTEC takes to aid early influence efforts. All of these early influence efforts culminate in the OT plan with integrated test events. By collaborating with all stakeholders through the early influence process, AFOTEC enables delivery of warfighter capabilities faster, with more confidence, and meeting the increased demands on T&E to rapidly replace current airframes.

Conclusion

AFOTEC action officers have worked directly with developmental testers, planning to eliminate test redundancy and capitalizing on data sharing during integrated test events. The efforts have focused on synergizing test events and objectives. Further ITT meetings will incorporate system group and user logistic representatives as well as requirements, tactics, current operations, and information assurance representatives to reduce test redundancy and capitalize data sharing on similar test events.

In the introduction to this article, we concluded that IT requires the following:

1. collaborative planning and execution of test events;
2. shared data;
3. stakeholder independent data analysis, evaluation, and reporting;
4. establishing risks and risk mitigation to decision makers in a timely manner;
5. efficient use of limited assets, reducing overall time required for testing;
6. elimination of unnecessary overlap of test events; and
7. documentation in an OT&E plan with integrated events signed by the OT commander and acknowledged by the PEO.

The KC-X, C-130J, JCA and E-3 DRAGON programs, through the establishment of their ITT and early test planning efforts, are meeting the collaborative planning requirements outlined in DoD instructions and senior leadership directives. Personnel from the program office, user command, FAA, developmental and operational test organizations are already collaborating on the test program. Additionally, creation of the E-3 DRAGON and KC-X test events integrated planning matrix and OT&E plans with integrated events support collaborative execution of events and the ability to share the data from those events, leading to test optimizations. The optimizations ensure the most efficient and expedient utilization of limited assets and eliminate unnecessary test event overlap. Construction of the ITEM and sharing the document helps communicate the IT concept, allowing the test community to begin defining their test plans before the contract is awarded. Including the ITEM in the TEMP will also highlight test risk areas.

The mobility and surveillance aircraft IT planning should yield significant economies, while reducing the overall test footprint and expenditures. The results can achieve shorter acquisition timelines, while balancing cost, performance, and schedule requirements while meeting the demand for air asset requirements in the 21st century. ❑

Major Douglas Kaupa currently is attending the Air Force Institute of Technology, earning an astrodynamics engineering degree en route to instructing astronautical engineering at the U.S. Air Force Academy. He is a former test director and KC-135 instructor pilot at the Air Force Operational Test and Evaluation Center (AFOTEC), Detachment 5, Edwards Air Force Base (AFB), California. As the senior KC-X and E-3 DRAGON test director, he was responsible for test planning, training, readiness, and test execution of 25 officers, civilians, and contractors with test budgets in excess of $10 million. He has a bachelor's degree in astronautical engineering from the

Air Force Academy and a master's degree in aerospace science from Embry-Riddle University. He also holds Level III Test and Evaluation and Level II Systems Planning, Research, Development, and Engineering (SPRDE): Systems Engineering acquisition certifications. E-mail: douglas.kaupa@afit.af.mil

MICHAEL WHELAN is the division chief for the test support division and a senior engineer, Air Force Operational Test and Evaluation Center (AFOTEC), Detachment 5, Edwards AFB, California. With over 24 years of test and acquisition experience, he is responsible for 20+ detachment programs covering bombers, unmanned aerospace vehicles and mobility platforms. He holds a bachelor's degree in electronic engineering from New Mexico State and a master's degree in computer engineering from the Air Force Institute of Technology along with Level III Test and Evaluation and SPRDE acquisition certifications. E-mail: michael.whelan@edwards.af.mil

Endnotes

[1]DRAGON = DMS (Diminishing Manufacturing Sources) Replacement of Avionics for Global Operations and Navigation.

[2]The KC-X acquisition strategy is under review within the DoD and may change in the future.

References

DoD. 2008. Department of Defense Instruction, Number 5000.02, December 2, 2008.

Eck, J. K. 2008. "Memorandum for AFOTEC personnel," Integrated DT and OT planning, October 17, 2008. Washington D.C.: HQ AFOTEC.

McQueary, C. E., and J. I. Finley. 2008. "Memorandum for component acquisition executives," Definition of integrated testing, Office of the Secretary of Defense, April 25, 2008.

U.S. Code, Title 10, Section 139, "Director of Operational Test and Evaluation."

U.S. Code, Title 10, Section 2399, "Operational Test and Evaluation of Defense Acquisition Programs."

Acknowledgments

Mr. Kelly McBride and Mr. Peter Ulrich, WBB Consulting, provided invaluable insight regarding the integrated test definitions for the KC-X program and Office of the Secretary of Defense documentation.

Mr. Dave Benson, Mr. Dave Fedors, and Mr. Dave King (known as Dave-cubed) from the Air Force Flight Test Center's 412 Test Wing provided clear perceptions from the DT standpoint.

A special thanks to Lt Col Pete Ames, Lt Col Rajotte, Mr. Jim Royer, and Mr. Hal Crawford from the KC-X program office, charged with implementing integrated test for the KC-X program, for providing leadership in creating the ITEM, refining it, and keeping the entire KC-X test community moving ahead.

This article is approved for public release; distribution is unlimited.